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The impact of oil price fluctuations on common renewable energies in GCC countries

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ABSTRACT

The decline of petroleum resources is a real problem that needs to be addressed by the non-renewable energy policies applied by world governments. Renewable energies such as solar and wind sources, nuclear power, or hydrogen fuel cells may become viable alternatives to conventional fuel in the future. This study reviews the conditions of the world's leading oil producers for the coming 50 years, i.e. the Gulf Cooperation Council (GCC) countries. On the other hand, this study clarifies the share of renewable energies today and how it will continue to increase steadily.

This study demonstrates that the increase in oil and shale gas production will affect the GCC countries, especially kingdom of Saudi Arabia (KSA), the largest oil exporter in the GCC. The study demonstrates that the GCC have failed in the separation between economic development and energy demand in the past decades. Therefore, the GCC economies are among the least efficient in the world. The growth in energy consumption is faster than economic growth in the region.

Sustainable energy in GCC states has been considered since 2008. Resource efficiency programmes, clean technology research, alternative energy projects, green building codes, green economy strategies, and public transport systems have become a part of mainstream news. The GCC states have started to have a stake in the transition to sustainable energy. The GCC states have already undertaken some policy, projects, and sector-wide efforts. These projects, if implemented, will boost the investment, and its effect on the environment will be apparent. Many of these policies and plans, however, still exist only on paper. The green building codes and national solar targets has been discussed.

1. Introduction

The Arab world is central to the world's energy supply and energy production resources. The Arab world holds 49.6% of the world's substantiated oil reserves and about 29.1% of the world's natural gas. Its importance for the international energy markets cannot be over-emphasised. In 2011, the proven oil reserve of Arab world countries was about 43% of the world's total (713.6 billion barrels) [1]. The Arab world contains 22 countries, and 16 of these are producers of oil [2]. The entire Arab world produced over 26 million barrels per day (mb/d) in 2011. This number was ranked third globally in terms of oil supply. As a result, the Arab world has become the world's largest oil producing region [3]. The oil wealth of the Arab world has shaped its overall development trajectory. This situation is ensuring that Arab world countries are integrated into the international economic system.

These countries are the world's primary source of oil, and the global oil situation is unlikely to change in the near future. However, there have been many recent discoveries of oil reserves outside the GCC region such as shale oil in the USA, deep offshore in Brazil and oil sands in Canada. These countries are expected to play a fundamental role in international oil market dynamics.

The GCC was established on May 25, 1981 in Abu Dhabi. This council consists of six countries, namely the United Arab Emirates (UAE), Bahrain, Kingdom of Saudi Arabia (KSA), Oman, Qatar and Kuwait, as shown in Fig. 1. The total area covered by the GCC region is about 2,500,000 km^2. The estimated population of the GCC was about 46.8 million in 2011, while it was about 33.2 million in 2004. It is expected to rise to 52.8 million in 2016. The GCC countries' global Gross Domestic Product (GDP) increased about 29% in 2010 and reached about 1.4 trillion US$ in 2011 [4].

The GCC countries are mainly coastal regions on the Arabian Gulf. These regions are composed of dry deserts and have humid coastal climates with only two main seasons, summer and winter. November to March is the winter season where temperatures are around 26 °C and

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Fig. 1. GCC countries [4].

15 °C during the day and night times, respectively. The summer season is between April and September, where temperatures approach 50 °C. This can be lower near coastal areas due to high humidity (approximately 90%) and wind speed. Some mountainous areas are cooler with average temperatures in the range of 10–14 °C [5].

With the exception of Oman, rainfall is sparse and inconsistent in the region. Average rainfall in all countries is between 140 and 200 mm per year while Oman experiences rainfall of up to 350 mm/year. Rainfall in the winter months is a combination of north-westerly, winds from the Mediterranean Sea and atmospheric depressions, primarily in February and March. In coastal regions the rainfall is lower in summer. However, some years there is no rain or it rains very few times. In 2015, the region had heavy rains in some countries, which created problems since the infrastructure is not able to deal with this situation [6]. Moreover, the desert exposed to Shamal winds, which are forceful dust storms.

The growth in population in the GCC continues is prepared to increase rapidly. The population doubled in 2010 compared with 2005. The urban population is about 83% of the total population, with this number increasing hugely between 2005 and 2008 [7].

All sectors in the GCC, with varying degrees, have been affected by climate change. Climate change showed clearly in the GCC countries. Substantial warming has taken over the GCC countries between 1960 and 2010. Between 1960 and 2003, the cool days and nights occurred over this period and there were more warm nights throughout the region. Average summer temperatures increased across the area as a result of the impact of human activities on climate. These activities made the occurrence of warm summer temperatures more frequent and cold summer temperatures less frequent.

In this study the oil and gas situation in GCC countries, in terms of resources and prices had been revised and investigated. The high reduction in oil prices and the long period for prices instability was discussed. Also, the oil prices impact on the economics of the six countries in the GCC region has been analysed. The impact of this situation on energy resources, renewable energy investments and programmes, and economic has been discussed.

2. The economic strength of GCC countries

The GCC countries had a larger surplus than either Germany or Japan in the year 2012–13 due to higher oil prices boosting exports. The GCC countries have relied on oil as the primary source of income over the past decades, and their economies revolve around it. This rapid economic development resulted in increased growth of industrial development, leading to larger energy demand in the GCC region.

KSA, Kuwait, Iraq, and the UAE are among the world's ten largest producers of oil. 98% of the Arab world's total oil reserves come from KSA, the UAE and Kuwait along with Iraq, Algeria, and Libya. Substantiated oil reserves of KSA alone are more than 265 billion barrels, which represents about 16% of total global reserves [8,9]. The GCC region has a primary position in international trade of crude oil. The oil revenues can be considered as an essential source of affluence for the GCC region as a whole. This wealth has driven the socio-economic in the region and its growth. Hydrocarbon fuels still play a critical role as a domestic fuel, covering about half of the area's needs.

The energy consumption of the GCC countries has grown 74% since 2000 and is forecast to double by 2020. This growth in energy and electricity demand has synchronised with the high global concern over carbon emissions and climate change [10].

As an example, the domestic consumption of oil and gas of the KSA increased to about 69% in 2009 from its values in 1999. Meanwhile, the crude oil consumption for power in the KSA was estimated to be 582,000 barrels per day in 2011; this amount rose by about 340% from its 2006 level [11].

This large rise in consumption has caused the UAE, Oman and Qatar to mix their power generation with the energy from natural gas power stations. However, natural gas prices are not as cheap as they were in the last century. Another obstacle added to the increased power costs is the high pollution resulting from oil and gas production as well as their use in electrical power generation and transportation. The effort in curing the environmental damages resulting from pollution added to the increasing prices of oil and gas and electricity that is subsidised by GCC governments creates additional pressure on the financial affairs of these countries [12].

The GCC countries have realised the importance of using green generated power by using alternatives to oil and gas. This region has high solar intensity and enough wind velocities that can make these two renewable energies, the solution for the lack of electrical power generation and large pollution concentration in the region. The oil and gas subsidies that are used to produce electricity (the subsidised of both the fuel used and the generated power) might be used to build and construct new plants [13].

Solar power is the primary renewable energy that is ready to use in GCC countries. It is now economically viable thanks to many factors, such as the rise of fuel costs used in conventional power generation, the reduction in the cost of solar panels, and the real suitability for demand patterns which is high in summer where solar radiation is high. There was a traditional view among policy-makers of the GCC region that solar energy is still uneconomic compared with the abundant hydrocarbon resources in the region [14].

3. Oil dependence volume in GCC economies

Gulf Cooperation Council (GCC) members became global players, thanks to the increase in world oil prices from US$22 to US$147 per barrel during the period from 2002 to 2008. The geographical site between the East and the West with oil and gas -rich reservoirs have put the GCC countries in a position of influence in the global economy. Revenues from foreign exchange of up to US$912 billion have been achieved by these countries during this period [15,16]. In KSA, the national income from oil exports increased from US$42 billion per year in 1999 to US$307 billion per year in 2008. The UAE's national income increased from US$13 billion to US$87 billion for the same period. In Qatar, an increase from US$4 billion to US$27 billion was achieved during the same period. In Qatar, after a decade of investment in infrastructure in the liquefied natural gas (LNG) sector, it becomes the third greatest source of gas in the world. In general, economic growth for these countries reached 13% thanks to this investment in 2000. In addition, exports of up to 77 million barrels per year will be achieved in 2020 [17].

This vast wealth added to wise investment makes these countries individually and collectively very powerful economically and politically. The impact of GCC attitudes and policies in international relations has become highly important. It is crucial to clarify that some of the leaderships of GCC countries have changed, and a new generation and driving directions become the decision makers. These leaders have a high degree of education and great ability to make hard and fast decisions. Qatar and the United Arab Emirates became in this head shift towards geo- economic pattern. These two countries are working towards investment in emerging economies in the East World after weak investment in the Western economy in 2008 and 2009. As an example, Qatar Investment Authorities invested up to US$6 billion in the Agricultural Bank of China in 2010 [18]. Moreover, it has been associated with Asian partners in the independent group of energy and in the emerging industries of petrochemicals, plastic and aluminium [19].

The six GCC countries held the hydrocarbon incentive, so this council represents the most significant supplies of energy for the coming decades. Foreign dependence on these resources originates not only from the size of their reserves and production levels, but also from their small populations and low levels of consumption. The vast supply per capita of the GCC has allowed it to export most of its production and to become strong in international oil markets.

Oil has impacted development in the GCC Region, but it became its economic risk as well. GCC countries have relied on oil for its domestic energy demands. Moreover, many challenges arise: the high domestic demands for oil and energy have caused a drain on the oil producing regions. This environmental damage will cause substantial investment loss or unsustainable growth. The driving question of this study is what role will oil play in GCC economies over the long-term. Shortly, many GCC oil producers will have to considerable investments and efforts to develop the oil production wells and allow for private sector activity in oil and energy industries.

The GCC region has responded to oil requirement increases. These countries shared in the period between 1970 and 2004 total international production ranging from 25–42%. The overall oil production from the GCC region doubled between 1984 and 2004 [20].

This oil produced in these countries made their economies interrelated and dependent mainly on energy revenues. These countries do not have diversified economies and depend primarily on the export of this single commodity. Energy funds in the GCC countries provide a secure source of economic growth and industrial development. Furthermore, social and political stability rely on it.

Fig. 2 represents the world oil reserves and production by regions at the end of 2011. Table 1 illustrates the proven oil reserves and production in the GCC economies at the end of 2011 [21].

Oil production and exports have introduced many practical challenges related to the environment, sustainable development and future growth and prosperity. These challenges have emerged and need rational treatment to preserve the benefits achieved from oil. However, it has been unequally distributed within the GCC region. In the coming decades, the suggested feasibility is to increase the potential of the role of both national and cross-regional approaches.

4. Oil and gas price impacts on GCC countries

When Arab Spring reached Libya in 2011, considerable fluctuations in oil prices appeared on international markets. In this period, the production of light sweet crude oil reduced dramatically from 1.3 million b/d to only 60,000. This reduction equals around 5% of the total supply of Europe's oil. This phenomenon was mentioned to demonstrate the impact of political, social and military factors on oil prices. As the incomes of GCC countries are mainly from oil, its price fluctuations change the plans of these countries considerably. As oil prices have crashed to around US$45 and keep fluctuating, this makes the dependence on oil as a source of income non-reliable.

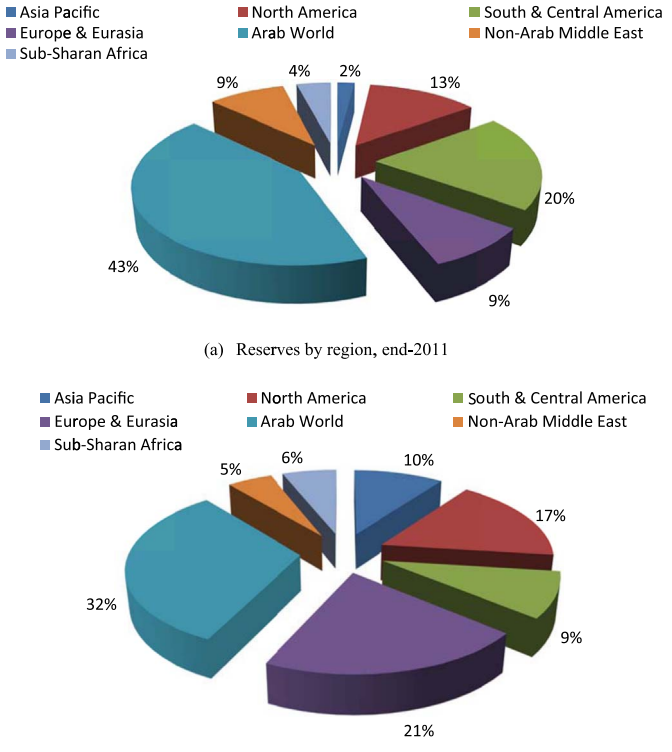

Fig. 2. World oil reserves and production by region at the end of 2011 [21] (a) Reserves by region, end-2011 (b) Production by region, 2011.

Almost the entire GCC region, from powerhouse exporters like KSA and Qatar, to the weaker ones like Iraq, Bahrain and Oman has tried to manipulate oil prices. In times of price fluctuations, as in the popular uprisings of Arab Spring, these governments consider their beliefs in the subsidies that may bring stability to their countries. Almost all of these countries increased subsidies hoping of reducing consumptions and increasing social securities. Bahrain, under the influence of popular demand and to balance the unrest, reacts by increasing subsidies by $425 million [22]. However, due to the significant increases in oil prices at that time, the high subsidies failed to halt inflationary issues and local concerns continued to undermine the legitimacy of the Bahraini royal family. Despite its large revenues, Bahrain still suffers from serious unrest. Nevertheless, Bahraini society is under examination, and the uprising revealed the intractable problem of sectarianism. However, all the previous factors, political, economic, and limits impacted the region's energy resources.

The wealthy GCC countries (KSA, Qatar and UAE) remained untouched by the unrest that affected parts of North African Arab states. The high capital reserves that these countries have enabled them to avoid the Arab Spring through subsidies. In 2012, when people in the UAE complained about gasoline prices, the UAE National Council unanimously elected to raise subsidies [23]. Unlike poorer neighbouring countries like Jordan or Egypt, the Emirati government relied on greater financial resources to fund the programme. The disparity between the region's countries (from energy importers' and exporters' point of view) brought the exporters into sharp relief due to their dependence on subsidies. The GCC region states (Kuwait, the UAE, Qatar, KSA and Iran) are considered the top five countries offering subsidies [24].

The uprisings during the Arab Spring led to turbulence in the energy markets, and in the meanwhile, no considerable or risk on supply occurred. Fuel price fluctuation presents significant financial risks that impact these countries' on five years plans. That is the main reason that the fuel consuming countries hedge their fuel costs.

Table 1
Proven oil reserves and production in the Arabian Gulf economies at the end of 2011 [21].

	Proved reserves (bbl)	Share of world reserves (%)	R/P ratio	Production ('000 b/d)	Share in world production (%)	Ratio export: consumption
The GCC States	495.0	29.9	69.5	19,505	23.3	58
Bahrain	0.1	< 0.05	7.0	47	0.1	5.0
Kuwait	101.5	6.1	97.0	2,682	3.2	7.7
Oman	5.5	0.3	16.9	889	1.1	6.7
Qatar	24.7	1.5	39.3	1,638	2.0	6.0
KSA	265.4	16.1	65.2	11,153	13.3	3.8
UAE	97.8	5.9	80.7	3,096	3.7	5.3

Moreover, there is another motive for improving or maintaining competitiveness [25]. The GCC countries were able to counter the potential for unrest by investing massively in subsidies and social welfare projects. As an example, KSA, the greatest export country in the region, responded to political unrest in the area by the new commitments reached about US$126 billion.

If we take the rate of growth in the annual budget expenditure of KSA, except for the year 2009, it decreased until the beginning of political unrest in the Middle East. Then, the following funds resulted in a significant rise in growth. After two years of Arab Spring, the KSA government budget grew by around 40%. In 2012, the Financial Times magazine demonstrated that KSA may need the oil price to a standstill in average more than US$100 a barrel by 2015–2016 to withstand its high public spending rises [26]. This proposed price represents a trebling in the oil price needed to balance the KSA budget in 2005. The current break-even price for KSA oil is US$80 a barrel, and in the United Arab Emirates it is just above that mark. These high prices not only will inflate real prices, but will also remove the pragmatic element of the KSA policy that allowed it to assuage the erratic behaviour of other producers through its production capacity. All sources indicate that the demand will rise faster than supply [27]. The pressure of the high KSA budget will reduce the possibility of KSA government control on prices.

The significant increases in oil prices in 2008 made some oil competitors to increase production. The debate about the significance of 'shale oil' is contested, circulating information such as its real potential, long-term sustainability, environmental impact, and economic feasibility. With regard to the high oil prices associated with Arab Spring, immediate significance was taken of shale to diversifying oil supplies. Shale is conventional oil extracted from unconventional formations of low porosity and permeability. The extraction takes place through a process of hydraulic fracturing (commonly referred to as 'fracking') that depends on horizontal drilling into rock formations followed by soapy water being pumped at high pressure. This procedure will cause tiny fractures in the rock formations from which the oil and gas can recover. The timeframe involved with the extraction of shale oil is radically different. Shale can be brought online within months and reaches peak production almost immediately. After that, the production decline is steep. Shale developers consequently operate on a much shorter time horizon, looking at short-term and exciting market conditions. Therefore, the turbulence of Arab Spring benefitted shale developers. The cheap Shale oil extraction and supply has relied on the rise in prices, particularly from the demand on a higher reserve price from GCC producers with relatively higher costs. The profitability of such fuel companies is constrained by some factors: the Middle East unsettled, the low price of oil and fluctuating. The full development of shale oil in the United States requires that the oil price be higher than US$ 80/b in the short-term and higher than US$ 65/b in the long-run (five years).

The development of sustainable shale projects will rely on more than just turbulence in the Middle East. One primary factor is economic recovery in the US and Europe that remains uneven and can delay the growth accompanied by the energy demand decrease. Organisation of the Petroleum Exporting Countries (OPEC) wills also pushback against perceived threats to its interests.

The GCC countries are concerned about the extent to which shale could threaten their oil exports. Many specialists in the oil region have warned that the GCC countries are threated from shale production. If these challenges taken in consideration KSA future export would need to increase its output from 12.5 million to 15 million b/d to meet its increased budget commitments. At the same time, if the shale basins are developed and start to export, it will mean a significant move in energy geopolitics away from OPEC countries.

Nowadays, the shale oil is concentrated in the United States, Russia, China, Argentina, and Libya. None of these countries is an OPEC member. The international abundance of shale reserves has not yet been fully realised. The United States currently leads the world in the extraction of shale reserves primarily because of the technological challenges involved of mining. These deviations relate to a range of technical factors, including the challenges posed by different rock formations and the need to continually bring a large number of new wells online.

Most of the GCC countries used a bargain by trading freedoms for welfare to boost social commitments. This is not an easy balance to maintain. Increases in social expenditure commitments have made GCC governments more dependent on higher reserve prices for oil to balance their budgets. This dependence makes them more susceptible to petroleum prices, and also delays long overdue domestic structural reforms. The usage of subsidy reformation was a definite sacrifice to achieve political stability. Many economic problems will expand the regional turmoil.

The demands for hydrocarbons as fuels in the transportation sector will continue to rise. Developing countries will have higher growth rates and China and India will be the leaders. The breakthrough in alternative fuels and vehicle engine technologies will affect the international oil demand causing a reduction by about 7 million b/d in 2035 compared to 2011 [28]. However, the GCC countries will remain in the next few decades the primary oil producers in the world. The survival of these countries as leaders in world oil markets imposes increased investments in the oil sector to increase the production capacity. It is wise for these countries not to depend on oil revenues, but to achieve multiplicity of income sources rather than complete dependence on a single source of income. Moreover, domestic energy demand and supply management must include a more diversified regional energy mix.

GCC region oil is distinguished by its longevity depending on its reserve base. The estimated lifetime is over 78 years. The estimated oil life of Kuwait and the UAE is over 80 years while in Iraq it is more than 100 years [29]. This picture does not reflect the entire region. Oman is considered a medium or small reserve holder, and the estimated depletion of its oil reserves, with the current rates of production, is a few decades; some studies estimate even less time than that.

Even by increasing technology usage to raise this production estimate, or at least maintain it at constant levels for some time, the lifetime of oil production for these countries is in sight. Therefore, all the GCC countries, especially Oman and Bahrain, have begun to diversify their sources of income. In particular, there is an emphasis on the exploration, extraction and export of natural gas [30]. However,

reductions in oil income are not compensated by the increase in natural gas exports.

The growing domestic demand for oil will force these countries to switch from being oil producers and exporters to oil importers. The pressing challenge facing the GCC countries today is its rising oil demand. Its demand has risen rapidly since the 1960s alongside the boom in energy consumption in the industrial and residential sectors. The dependence on oil may be no longer sustainable or suitable for the region's best long-term interests due to the rise in energy consumption in the area and rise in domestic oil cost by exporters and importers.

The oil producers in the GCC have faced many challenges in the last decade. These challenges have included investing in the energy sector accompanied with high uncertainty due to climate change. Moreover, an energy security policy aimed at reducing oil dependency. The technical and managerial capability of these countries reinforces to transfer their industries to extend the labour market for hundreds of thousands of workers each year.

5. The impact of oil and gas shortages

The development trajectory of the GCC countries has been shaped by oil wealth like no other region in the world. Oil was first discovered in the GCC countries in the 1930 s and the huge reserves in this area have turned GCC producers into the world's largest source of petroleum. In many situations, the area (in particular KSA) played the role of shock absorber for providing oil, relieving the influences of problems originated from outside the region. Oil revenues are the key source of wealth for the GCC region despite considerable differences in production and exports.

Oil has continued to provide about half of the region's domestic energy demands. Therefore, oil plays a critical role in the GCC region's energy mix, in the absence of any strong share of renewables or other alternative sources of energy. In the energy sector, the increasing demand for energy in the region, during this period, has become one of the most important challenges facing these countries [31]. In addition to increasing energy consumption in these countries, they face many other challenges. Investing in wells to increase productivity or in new wells to maintain these states' positions as key suppliers are displays these governments to extra problems. The slow response to the requirements of energy consumption may cause in numerous oil inability to respond to situations of oil share in energy. The output of oil export incomes could not match the high expenses to diversify sources of income for GCC countries. However, this makes the GCC governments to face the problem of increasing their income resources to fulfil their obligations. The political crisis in the surrounding countries of the GCC region may cause a decrease in oil production, causing uncertainty in the oil markets, in addition to the disturbances in the developmental plans of these countries. The GCC countries have become aware that wealth from oil does not come without associated problems. These challenges and their solutions will determine the future of the region. The dependence of GCC countries in their economy is mainly on fossil fuels to meet more than 97% of domestic energy demand, with a contribution of renewables by the remaining 3% [32].

This growth in energy relay is a result of the region's change in lifestyle, economic growth, and industrialisation. This outbreak in demand does not need to drive to a surge in air pollution as carbon emissions. The rational management of the energy demand and the shift to an efficient use of energy, generating higher output units for less input energy units, is overdue.

The burning of oil by major exporters such as Kuwait and KSA has reached historic proportions. KSA crude oil resources will fall by as much as 3 million b/d by 2028, while domestic crude oil consumption will grow continuously for much longer [33]. This is a growing concern reflecting the dilemma facing many GCC oil producers, i.e. the supply of domestic markets with low-cost petroleum products while preserving or expanding current exports.

Most of the developed countries have considered various methods for diversifying their energy suppliers and energy mix. For inadequate resources or poorer countries in the region, the determinations of this lesson have been acute. They realise the necessity of attracting funding from other provenances across creative approaches that can influence confined general principals to captivate momentous private investments. For Oman, which is among the largest countries in the reign affected by oil price fluctuations, the government started independent power production from natural gas. Moreover, the government experienced the benefits of the use of private sector participation in developing generation capacity. The renewable energy market in this country is rapidly expanding, as well as in other countries of the region. There is about giga-watt solar energy farms have started to be used for oil enhanced recovery to produce steam in Oman.

The supply of domestic markets with low-cost natural gas has led to many structural demand patterns supporting the use of oil as a fundamental energy source. Access to cheap petroleum products in the industry, including natural gas, can be considered as a low-cost input factor. This access will encourage investment in new, or the upgrading of existing facilities confirming the use of alternative fuels whose costs are subsidised. The high initial cost of investment in natural gas technologies appeared considerably reasonable about oil. It can be supplied domestically at very low prices like oil [34]. Table 2 represents the contribution of oil and gas to government revenues in GCC countries.

6. The tendency towards natural gas

GCC authorities used to consider natural gas to be a nuisance or by-product in the past without appreciating its actual economic value. Gas prices were almost constant linear, and much of it still linear due to governmental subsidies. The pressures from oil prices are the result of Arab Spring and alternatives such as natural gas are currently being explored to reduce the dependency on oil. Moreover, it is starting to contribute to Gross Domestic Product (GDP), as shown in Table 2. It should be noted that gas subsidies shape only a small part of the overall energy support in most GCC countries. Qatar, Iran, and UAE accounted for 34%, 31.6%, and 54.9% of the total energy support in the year 2010, respectively. The GCC region has the lowest wholesale price for gas in

Table 2
Oil and gas sector contribution to GDP (nominal) and government revenues in the economies of GCC countries [34].

	GDP (US$ millions)	Hydrocarbon sector (US$ millions)	Share of hydrocarbon sector (%)	Share of international GDP in total Arab GPD (%)	Share of hydrocarbon revenues in total government revenues
The GCC States	1,084,391	479,547	44.2	53.5	80.7
Bahrain	22,945	6691	24.4	1.1	81,8
Kuwait	124,244	64,009	51.5	6.1	93,8
Oman	63,199	30,118	47.7	3.1	81,7
Qatar	128,593	71,642	55.7	6.3	60,8
KSA	447,762	214,145	47.8	22.1	90,4
UAE	297,648	94,042	31.6	14.7	75,9

the world. As a result, the natural gas consumption in the GCC region has doubled over the preceding decade [35].

As many of the GCC countries have large reserves of natural gas, this fuel can help the region to meet its energy needs as well as to manage its global carbon footprint. This issue results in gas prices in GCC countries being kept at low levels, which not only has contributed to the rapid growth in gas demand in the region but also has added new energy sources. The necessary investment to direct the GCC to the energy diversity requires is not a challenge due to large oil revenues. The GCC region was for a time among the least economically integrated regions in the world, hindering regional natural gas market development. The gas trade is authentic on far-away markets due to a lack of regional gas trade. Only about 11% of GCC pipeline gas shipments are exported and consumed in the GCC region.

The GCC region has failed to decouple economic growth and energy demand in the past decade. Therefore, the GCC economies are among the least efficient in the world. Energy consumption growth is faster than economic growth in the region. The annual increase in energy and electricity need has been about 8%. Subsidies on fossil fuels can be considered as the primary contributing factor to this inefficient use of energy. The region's residential markets are the most heavily subsidised; it sometimes reaches 95% of residential energy consumption in some countries. An important factor causing this is the weak electricity infrastructure in most countries in the region [36].

The increase in gas demand is driven by the fast-growing electricity needs in the region (8–10% per annum) and by the growth in the energy provided to the industrial. This allows natural gas to play a significant role in the future of GCC energy, and economic development demands a change in energy policy across the region. The focus must be on reforming prices and private sector involvement. Natural gas and related energy product prices must be reformed in a way that initiates a move to sustainable energies in the long term. Natural gas can play an important role in the GCC energy transition and the region's future economic development. As well as the region passing through a period of political and economic changes, these countries are undergoing an energy transition that reveals itself as a changing role in global energy trade markets. Natural gas as a fuel has the potential to play a significant role in this transition [37,38]. Fig. 3 shows the Arab primary energy supply 1971 vs. 2010.

The demand for gas in Arab countries has grown at an average rate of 6.1% in the last decade, reaching some 330 billion cubic meters (BCM) in 2011, as shown in Fig. 3. The GCC countries have the fastest growing markets among the Arab nations. The electrical power sector is the main driver of the growth of natural gas demand in those countries, followed by the industry sector and in particular with petrochemicals industry. In 2010, gas approached more than 51% of total fuel consumption in the GCC electrical power sector, with relatively wide variations between countries. Electricity consumption has increased by an average of about 8–10% per year since the beginning of the 2000s, led by rapid economic, demographic and urban growth rates in most countries in the region, and natural gas demand has followed a similar trend.

The demand for gas in the GCC countries depends on the end user price of this material which is considered as the lowest energy cost in this region. Gas prices in seventieth and eightieths decades of the last century were reasonable at the time, but are not suitable now [39]. Natural gas prices are 0.8–1.5, 0.75, 0.8, 0.75 and 1.0 US$/MMBtu in Kuwait, UAE, KSA, Qatar, and Oman, respectively, and are considered to be very low. These prices do not reflect the true value of this material. These low prices encourage high consumption and therefore increase the local demand, causing great influence on the exported fuel. Fig. 3 represents GCC gas production where the average rate has increased by 6% to reach about 500 billion m^3 in 2011. However, this growth was driven by Qatar to a large extent starting from the mid-2000s, whose income increased more than five-fold between 2001 and 2011. In KSA, interest in the natural gas industry began as late as 2009.

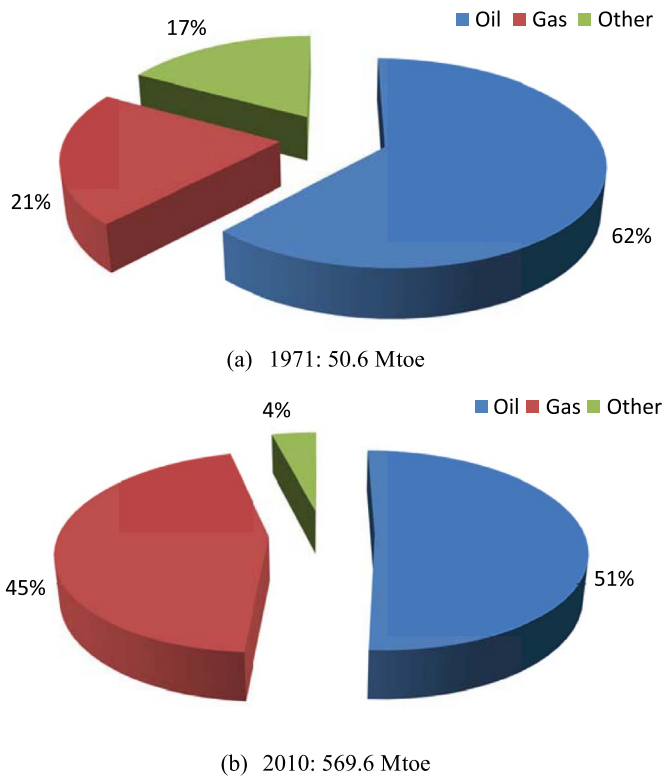

Fig. 3. Arab primary supply: 1971 vs. 2010 [38] (a) 1971: 50.6 Mtoe (b) 2010: 569.6 Mtoe.

As a result, the KSA effort to shift to the non-associated reserves development which caused an increase in gas supplies in the period 2009–2011. Kuwait and the United Arab Emirates adopted the same strategy in 2011 [40].

Qatar is perhaps the only country that can increase its gas exports before 2020. It can achieve that in the penetration through the bottleneck, which is the increasing gas liquefaction, with new export projects concurrently with explorations in the North Field. The relationship between natural gas supply and demand will always be associated with domestic consumption, and Qatar is not an exception to this rule. This will cause a budget deficit that will be clear by 2020.

The Arab region is one of the least economically integrated in the world due mostly to the private sector's weakness and a lack of political willingness to integrate. The Arab Gas Pipeline (AGP) and Dolphin are the only two regional pipeline projects and in 2011 they represented 12% of Arab natural gas exports [41]. There are two main factors behind the failure to build a good market for Arab natural gas. The first factor is related to old exporting countries (Libya, Algeria and the UAE), since the gas market in the region is small to justify regional transport infrastructure investments. Financial guarantees and long-term off-take is crucial for foreign investors and create important markets in Asia and Europe. The US could justify and provide the necessary commitments for this development in both LNG and pipeline.

Secondly, despite the emergence of many markets for natural gas, importers for the GCC natural gas falling in areas far away from GCC region. Perhaps the reason for this may be the decrease in trust between neighbours. The countries that suffer from a deficit in their budgets do not try to import gas from the region. Therefore, some of these countries cannot enter into competition with cheap producers of energy, and these countries consider import gas from its neighbours shows its dependency and needs [42]. However, in the 2000's, these countries felt their needs to buy gas with global prices. So that it has to overcome some political differences with its neighbours to ensure continuous processing of gas. Securing local growing demands for

energy may cause to reduce the permit gas to neighbours, and knock the countries with economies in embarrassment in front of buying gas at precious global market prices option.

However, the decline in US gas prices and lower European demand may encourage GCC gas exporters processing of their neighbours [43]. In recent years, inefficient policies slowed the trend towards improving the efficiency of production and exportation to these countries and created new opportunities. Natural gas can be an important player in the region energy needs, taking in consideration the population and industrial development in the region. In fact, natural gas, as a result of its cleanliness and abundance compared to the other fossil fuels, can fulfil all of the GCC processing needs. Overall, the energy diversity remains the ideal solution to provide GCC countries requirements in the region [44].

7. The impact of oil and gas production on domestic GCC policies

The demand for energy will continue to grow at a constant rate in the coming years, even with the absence of adequate planning methods for fuel consumption and energy efficiency. The region's laws regarding trade in oil and gas will be the measure for the extent to which it can be accessed in the oil and gas consumed domestically, compared to the internal energy demand. Natural gas, which has many reservoirs, makes it a fixture in insuring the needs of the region's energy, as well as reducing the dependency on oil. However, what are holding back the developments of the gas industry in the region are defective and routine laws. Despite the increase in gas consumption in the region, it is still not the best option for some countries. The laws prevailing in the region should be reconsidered, these which are for determining gas prices and the liberalisation of its industry to give the private sector good with its excellent capabilities the opportunity in developments of the gas industry. Although there are some signs concerning the development of laws, there is a need to the socio-economic of the government to accelerate law legislation. The GCC governments have to develop a clear vision of sustainable development in their countries for the development of energy systems by improving economic to make it solid and continuous on extended period. Still to this day, it is not clear whether the governments of the GCC see natural gas as a future substitute for oil in reducing carbon dioxide emissions. However, till such a vision exists, efforts should be made to develop the laws towards strengthening natural gas as the energy consumed in the region and these efforts must be a priority [45].

Investing in the energy sector in the GCC is linked to local and international issues. Oil revenues will remain the main source of income in these countries, making it play a key role in the social and economic development of these countries. To achieve political stability, social development and economic well-being, it is important to maintain an efficient oil sector and effective development in oil production capacity. For those countries whose oil productivity declines, the solution lies in investing in complex technologies to extend the life of its wells and their productivity. It is important to increase revenues to the fullest extent, but one has to wonder how this can be done. The investment in the oil sector has global ramifications as long as greatest global projects increase the demand for oil, which is to be responding through the Arab OPEC countries [46].

Geopolitical issues have a direct impact on the increase in production capacity of the GCC region, for example, the Iran -Iraq war (1981–1988), the Iraqi invasion of Kuwait (1990), the US-led invasion of Iraq in 2003 and the chaos and insecurity following this invasion of Syria and Iraq. It should not be forgotten that oil theft by terrorists, who have constructed a new market for stolen oil, is preventing the governments of these countries from important sources of income to invest in the oil sector. In Iraq (which is located close to the GCC region), internal conflict has continued since 2003. Similarly, the inability to develop and legislate new laws for oil and gas caused a delay in the approval of many development projects and investment in the oil sector. Political unrest affected the GCC and caused economic losses for these counting between 2011 and 2012.

In a country such as Kuwait, the relationship between the owner of the natural resource (the government) and the national oil companies extracting the resource is highly inefficient, yielding low rates of investment. Until today, the aim of modifying the economies of the GCC to make the region less dependent on oil wealth remains largely unattained. The oil sector's share in many economies of the GCC has remained exceptionally high, challenging all previous plans devised to reduce this percentage significantly [47].

8. The effect of oil price fluctuations on GCC economies

Today, this story is beginning to change. The growing population and consumption of the oil and gas exporting countries threatens the assumption that GCC countries will continue with constant exports [47]. If the current rate of consumption continues in KSA, this could lead to a decline in the rate of oil exported by the end of this decade [48]. However, oil production in Oman and Bahrain, the two GCC countries with the least natural resources, is declining and their oil supply is nearly depleted. The exportation of oil and gas formed the bedrock of the political economies of the GCC.

The dilemma of consuming high rates of energy coincided with the time that all Arab countries forced to move in reformations due to the revolutions of the Arab peoples and shows several questions to tribal authoritarian regimes. Energy consumption in GCC countries has risen dramatically in the past four decades. In 1970, these countries were poor and underdeveloped, and had small populations because of centuries of isolation. For this reason, the rising consumption in this region has caused a dilemma for global demand. Forty years later, these countries account for a total population of 0.5% of the world's population yet consume 5% of the total oil produced. Fig. 4 compares the average yearly growth in energy consumption for two periods of time. Table 3 illustrates the GCC primary energy consumption projections up to 2020 [49].

Most oil produced in the GCC is exported. However, the domestic use of oil is on the rise. Between the years 2000 and 2009, consumption of petroleum grew by an average of 6.5% per year. Oil production consumed domestically in 2009 varied from an average of 13% in Qatar to 26.5% in KSA [50]. The high consumption of energy in KSA has made it one of the world's highest energy-consuming countries. Despite the small population of the KSA and the limited industrial base economy compared to other countries such as Brazil and Germany, it surpassed them to become the sixth highest consumer of energy in 2009 [51].

Domestic oil consumption with global demand both has accelerated the entry into strength of its reserves. KSA was reported to have achieved the highest level of oil production in 30 years in April 2012.

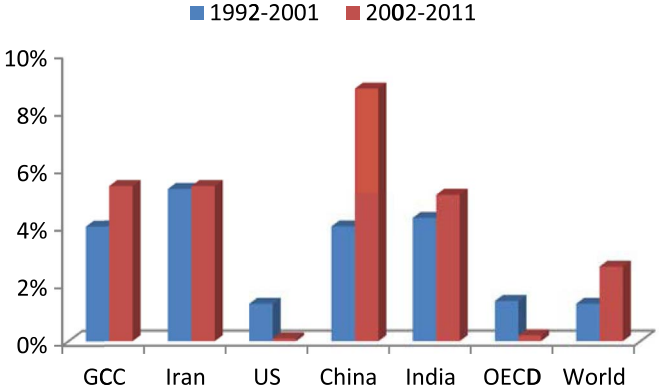

Fig. 4. GCC energy consumption vs. others [49]..

Table 3
GCC primary energy consumption projections up to 2020 (million tonnes of oil equivalent, a: forecasted) [49].

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 (a)	2017 (a)	2018 (a)	2019 (a)	2020 (a)
Bahrain	8.6	8.9	9.3	9.6	9.8	10.7	11.4	12	12.7	13.2	13.8	14.3	14.9	15.4	16.2	16.8	17.5	18.3	19	19.9	20.7
Kuwait	21.6	20.9	21	22.8	23.9	27.5	26.9	28.1	29.8	30.5	31.7	33	34.3	35.6	36.9	38.4	39.9	41.4	43	44.6	46.4
Oman	8.6	8.7	9.1	9	9.6	12.3	14.1	14.5	15.3	16.1	17.1	18.1	19.2	20.3	21.5	22.8	24.2	25.7	27.2	28.8	30.6
Qatar	14.6	11.3	11.9	13.2	15.9	19.7	21.1	23.5	26.4	29.2	35.2	41.4	45.3	48.9	52.5	59.2	65.7	72	79.1	87.1	96.3
KSA	114.6	121.3	127.1	133.9	144.2	153.2	160.1	169	179.1	187.8	198	208.8	220.5	233	246.2	260	274.5	289.9	306.2	323.4	341.6
UAE	42.5	43.1	46.8	47.7	50.3	52.4	55.9	60.5	66.3	67	70.1	73.7	77.8	82.2	87	91.7	96.7	102.2	107.9	113.9	120.2

An important part of this production was preparing oil for use during the summer months for domestic purposes such as air conditioning demand [52]. Nowadays, the high summer electricity needs have forced KSA to import heavy fuel oil feedstock [53]. At the same time, the demand for oil for electricity power generation has reduced exported oil quantities, and as a result, state income in Kuwait. Fuel consumption accounted for 12% of the country's oil production for power generation in 2010. This ratio will continue to increase to 21% by 2030 [54].

The Gulf countries can be considered from those adopted almost entirely on oil product. The economic size of these countries is represented by the export of oil and revenues have reached 83% of total government income [55]. From an economic point of view, the dependence on one source of income is risky. There is no link between the energy prices in the GCC and the value of the energy in six countries. As a result, these low-energy values cause large and wasteful consumption. In these countries, the price of a litre of gasoline is less than the price of a litre of water, which gives an impression to the consumer to waste this cheap energy. This cheap energy caused disabling investment in this area at the same time caused by the waste [56].

GCC countries are exposed to the depletion of oil in the near future, depending on the production rate compared to the sources that they own. When these countries reach the oil producing stability state, the export rate tends to decline while the domestic consumption of energy increases. This phenomenon is a natural and straightforward recipe for the depletion of natural resources for oil-exporting countries. There are two solutions: first, an increase of oil prices to the extent that it reduces exports, thereby reducing the resulting income. The second trend is the increase in fuel prices and energy assigned for domestic consumption. Both export and production will decline as depletion approaches. When exports are smaller than domestic consumption, the state becomes a net importer. This scenario shows that to obtain the greatest benefit from natural sources, the wise use of local energy is important [57].

Several factors have caused a delay in the regional integration of the GCC countries. The GCC countries can be considered to be competitors in oil and hydrocarbon production markets. The necessary coordination in industrial and economic policies in the region becomes difficult to be planned. The similar production structures result in very low rates of intra-regional trade. The internal trade (imports and exports) between the GCC countries averaged about 7% between 1995 and 2011, compared to their trade with the EU and Asian countries, which reached 63% and 23%, respectively [58].

The reduction in hydrocarbon dependence is one of the main challenges for the GCC countries. The region's governments have to take several well-studied strategies to meet this objective. For example, KSA, the region's biggest oil producer, has worked to develop industrial activities related to the oil sector, such as polymers, plastics, and fertilisers via the state-owned SABIC Company. The United Arab Emirates and Bahrain choose to develop tourism, manufacturing and financial services. Qatar has selected another alternative by strengthening its gas and financial sector [59].

Until now, these efforts have resulted in some positive outcomes, such as a reduction in the dependence on oil revenues and less vulnerability to fluctuations in the price of oil. Of course, there are still some indications; as an example, the Kuwaiti and KSA manufacturing sectors have started to disengage from the oil sector. On the other hand, the Qatari economy is still affected by oil price swings (except its manufacturing sector) [60].

Despite their many common institutional characteristics, the GCC countries have failed somewhat to behave as a unified bloc. This failure includes structural economic and geopolitical factors that have made regional integration difficult. For example, in 2004, independently from her other partners, Bahrain signed an FTA with the US [380]. This agreement reinforced the US military's presence in the Gulf because of the wars and instability of this region. The precious

Table 4
Installed renewable energy capacity in GCC countries (2012) [70].

Country	Solar-CSP	Solar-PV	Wind	Others
Bahrain	N/A	5 MW	0.5 MW	N/A
Kuwait	N/A	1.8 MW	N/A	N/A
Oman	N/A	0.7 MW	N/A	1770 MW (Hydro)
Qatar	N/A	1.2 MW	N/A	40 MW (Waste to energy)
KSA	N/A	19 MW (2013)	N/A	N/A
UAE	100 MW (2013)	33 MW (2013)	N/A	1 MW (Biogas–2013)

resources of the GCC region added to the weak economy and its growing importance in this part of the world have resulted in the development of important political and commercial links with many countries, chiefly with the US. GCC countries have signed many international agreements, and are affiliated with many international summits and negotiations [61].

New issues have added to the stable economic development, increased energy requirements, fossil fuel depletion and the direct effect of fossil fuels on climate change due to the effects of carbon emissions on the atmosphere. There are two effective ways to reduce fossil fuel dependence: reduction in energy consumption by applying energy saving programmes, energy conservation and efficient energy usage in the industrial and domestic spheres [62]. Secondly, by developing renewable energy as it is an effective alternative energy with reduced carbon emissions.

9. Alternative energy utilisation volume in GCC

The GCC region has many rich natural resources of renewable energy; it receives high solar irradiance that is very well matched to meet the high summer demand for electricity. The weather conditions of the region are very suitable for the production of electrical energy using renewable energy sources, which will be more economical to use here than any other place in the world [63]. The region is appropriate for PV and solar thermal applications on a large scale taken in consideration the vertical direct radiation is promising, which ranges from 2050 up to 2800 kWh/m^2/year, with little presence of clouds do not exceed only 20% of the year. This is one of the best rates in the world, which means that the region is well suited for solar heating and cooling applications, Concentrated Solar Power (CSP) and solar cell applications. The International Energy Agency (IEA) has estimated that the use of CSP technology alone can generate hundreds times of electricity in this region, more than is consumed by the Arab region and Europe together [64].

The GCC region is considered to be well-suited for the application of solar Photovoltaic (PV) since the Global horizontal irradiance (GHI) is relatively high, which is the appropriate measure of anywhere to solar PV work, ranging from 1920 to 2450 kWh/m^2/year. These are the highest possible values measured in the world.

The summer demand in the region is about 10.8 GW, and this demand supplied from combined-cycle turbines fuelled with cheap legacy gas and expensive imported LNG. By using solar power plants that can introduce about 3.5 GW of nominal PV capacity, the optimal generation mix changes. Managing the early-evening peak remains a challenge for solar PV. There are many possible solutions, including thermal storage, energy storage (e.g. pumped storage where available), production of portable water at off-peak times and electricity trading with neighbours at irregular peak times. These solutions have become economically attractive as they have less capital cost compared to gas turbines [65].

It is estimated that the first adopters of solar power will be the UAE, KSA and Dubai. These countries have effective economic reasons for employing solar technologies. None of these states were seriously affected by Arab Spring uprisings. The next form of solar development may vary. Many PV projects are under construction in the GCC [66]. However, other technologies are also proving popular for generating electricity, such as some solar water desalination schemes. Whatever the final figures are, if the expertise and available plans are any guides, the real diffusion of the solar energy applications will be clear. The large projects currently underway such as the Mohammed bin Rashid Al Maktoum Solar Park promise to attract both interest and investment to the area [67,68].

The estimated proportion of the productive capacity of solar and wind power is about 0.5% of all produced electricity in the region. The production of solar cells increased thanks to the high intensity of solar radiation and the clear decline in cell prices. The productive capacity of solar cells has begun to grow rapidly. In the United Arab Emirates, a station with a production capacity of 33 MW started operating in 2013 and was followed by a plant in KSA with a capacity of 19 MW. There are many possibilities of taking advantage of applications of geothermal, biomass and waste-to-energy in certain areas of the region. In KSA, there are sites with temperatures of up to 200 °C at a depth of 5000 m [69]. Table 4 illustrates some of the sources of renewable energies that indicate the great potential of the Gulf. The United Arab Emirates and Qatar can be regarded as the only countries in the region that produce electricity by biomass and waste technologies, although the rates of production are low [70]. Table 4 analyses the established capacities from renewable sources for each state, according to the technique used.

Wind and solar as renewable energies are well known to be variable, however, they are cyclical and can be predictable. There is significant solar radiation intensity in the GCC region, but also, there are many problems related with sand and dust movements and their accumulation of solar panels. This problem introduces a primary challenge for the implementation of solar energy in the region. Fig. 5 shows a picture of the dust storm impact on a PV array in Qatar and its capital city Doha [71].

Despite the small size of renewable energy technologies established in the GCC countries compared with other regions of the world, a different picture emerges when assessing the pipeline project. There are currently several renewable energy projects of up to 6.4 GW, including hydroelectric power, under construction or at the planning stage across the Arab world [72].

In 2010, the multibillion-dollar GCC power grid project to interconnect and integrate electricity network. This network will create 100,000 MW of additional power over the next ten years to meet demand for the estimated $100 billion dollars. The states involved are KSA, Qatar, Bahrain, Kuwait, Oman and the United Arab Emirates. Thirteen contracts will be awarded in the first phase worth US$1.25 billion to link KSA with Kuwait, Bahrain and Qatar [73].

The GCC established private financial resources for investment in the field of alternative and renewable energies. This investment will be in the form of soft loans or other banking facilities for research, education, teaching, training, and standards. In 2013, the Omani government launched its policy of grants and credit in the field of

Fig. 5. Illustration of a typical dust storm in Qatar [71].

alternative and renewable energies for small and medium-sized projects and research leaders in this field. The programme aims through these advanced grants to guarantee the entry of developers into this area in the country [74].

The United Arab Emirates established the Masder and Taqa cities, which are subsidised by the government. These cities are the sources of renewable energy in this country. The UAE transferred through these cities, a governmental grant in the field of renewable energies around the world and locally. At Masder, for example, in 2013 it began operating (Shams 1) a commercial station with a 100 MW CSP plant. At the same time, work was at the final planning stages for the 100 MW PV plant called Noor 1, in addition to a wind field of 30 MW capacity near Sir BaniYas village. This is in addition to several grants for renewable energy projects carried out by Masder for the Government of the United Arab Emirates in Afghanistan, Mauritania, the Pacific, and the Seychelles. In addition, soft loans were allocated by the Abu Dhabi government to Third World members of the International Renewable Energy Agency (IRENA) [75].

More than a dozen projects have been granted with values of up to 1 billion US$, the first of which is the giant project linking Kuwait, KSA, Bahrain and Qatar. There are also several plans to increase the capacity of the network and the six countries to be linked to other countries such as Iraq, Jordan, Turkey, Egypt, and Morocco. Furthermore, across this network, the GCC electricity system will be linked to the European power grid through Morocco from the west and Turkey from the north [76].

Qatar Airways, 50% of whose shares belong to the Qatari government, established an initiative to develop and use biofuels in aircraft. The pilot project is funded by the Qatari government. Qatar Airways have several support parties such as Airbus, Rolls Rice, Qatar Petroleum, and Qatar University for Science and Technology. This group formed the basis of Qatar's programme of advanced biofuels. This consortium aims to develop the first plant to produce fuel jets from a large field of algae in the world. In the first phase of this project, the University of Qatar will lead a number of research and technology groups to establish the average size of the algae field and the establishment of a laboratory to produce bio-fuel [77]. The United Arab Emirates' Etihad Airlines has participated with the Masdar Institute of Abu Dhabi to explore and produce biofuels from algae. Also, Dubai has steadily began to develop programme to convert cooking oil into a fuel for trucks. Oman has demonstrated a significant wind potential, with speeds that meet the threshold and full-load wind hours of 2708 and 2463, respectively [78]. Moreover, a new programme was initiated in the Research Council of Oman to invest in applied research in renewable energy.

10. GCC regional investment in the renewable energy sector

Up to today, the GCC's investments dedicated to renewable energy have been mainly financed by governments. The governments of the Emirate of Dubai and KSA were the first in the region to establish new renewable resources to increase the national income. Some GCC countries have created a private sector to increase the tendency toward local and international renewable energy projects [79]. Some GCC countries have opted to use existing financing channels to fund renewable energy projects. This approach is a typical method, but not the only one that oil-exporting states can use as these countries have large, well-capitalised energy companies. Therefore, many newly created renewable energy investment units originate from state-backed energy businesses in Kuwait, Qatar, KSA, and the UAE [80,81].

In KSA, an increasing energy demand has been accompanied with economic growth while electricity generation capacities have increased. The increase in the generation capacity was 13% per year between 1971 and 2009 and about 6.2% from 1999 to 2009. By applying an estimated similar annual growth rate (6.2%) for the future years, 300 TWh supposed to reach in 2015. The peak power demand will rapidly increase in the next 20 years. In 2000, about 24% of the gas and oil was produced to cover the domestic requirements. In 2010, this share rose to 35% and expectations is that more than 40% of the produced gas and oil will be required to cover the domestic demand by 2020. Furthermore, the consumption of domestic oil is expected to surpass oil exports by the year 2025. This domestic oil consumption trend jeopardises economic growth [82].

KSA plans to introduce a support scheme for renewable energy. Details of the programme are still under discussion, but a decision is expected in the short term. In KSA, high solar irradiation PV is a cost competitive alternative. Oil and gas electricity generation plants can utilised flexible to be integrated with the renewable generation technologies. Solar energy has an enormous offsetting potential and it can replace part of oil and gas power plants and selling the oil to the world market instead of currently used for domestic power generation [83].

The KSA renewable energy programme will not be limited to cost-efficient power generation alone. KSA plans to have a local PV industry: the quick solutions for existing problems in the crystalline silicone-Si PV value chain (i.e. the production foundation for metallurgical silicon and solar cells) will result in many advantages for all involved. The selection of the right technological method and the specific characteristics of the region could be taken to demonstrate attractive niche markets. Four cost groups determine the viability of a scattered or co-located integrated PV: labour costs, local procurement conditions, stable electricity prices and depreciation on fixed assets that are amongst the lowest in the KSA [84].

In February 2011, the Polysilicon Technology Co., Ltd. announced that it was preparing to build a 15,000 panel's production facility. This announcement made it clear that KSA aims to provide the PV power plants with locally manufactured products. This ambitious targets became even more evident after Green Gulf released plans to construct a 750 MW wafer and 200 MW module plant in June 2013. Closing the gap between existing quartz mineral (SiO_2) natural resources and module production is an important strategic motivation for the integrated silicon-based production infrastructure institution in the KSA [85].

Currently, the largest PV plant in the GCC region is Environment's 10 MW PV plant in Masdar City, Abu Dhabi, UAE. The plant includes the first Solar CdTe thin-film modules and c-Si technologies. Some other projects have been approved or are under way. However, the project timelines are often marked by crucial delays. A combined speculative venture between Total, Masdar, and Abengoa is building a 100 MW CSP plant in the UAE at present. This project reached its financial close on March 7th, 2012. The Shams 1 plant employs a parabolic trough design, and the project was expected to be completed in 2012. A 10 MW solar project using CIS modules furnished by Saudi Aramco offices Solar Frontier can be considered to be the most advanced large PV project. The Al Midra project, when completed, will be the biggest PV project globally for car park [86].

The UAE, as the leading state for renewable energy development in the area, is also conducting two ambitious ventures. Dubai's Mohammed bin Rashid Al Maktoum Solar Park is the largest announced project to date in the area. This project aims at 1 GW of PV and CSP power generation by 2030. Sheikh Mohammed bin Rashid Al Maktoum, the current UAE VP and Prime Minister/Ruler of Dubai, assigned US$ 3.2 billion, 48 square kilometres park to install solar plant. Dubai's Electricity and Water Authority is appraising tenders from contractors to construct the plant. This project is not the first such scheme in the UAE. It follows on from the Masdar City project, a planned city, which will depend on renewable energy entirely for its electricity demands. The planners of Masdar City aimed at a population of 45,000 to 50,000 inhabitants, in addition to 1500 job opportunities. The first tenant in the city is the Masdar Institute of Science and Technology [87,88].

The availability of potential solar resources and financial support is

the important element to develop the United Arab Emirates renewable energy market. A creative Building-integrated Photovoltaic (BIPV) placed in big buildings has been developed faster than expected. The off-grid PV equipment used for public lighting, remote desert and isolated areas could represent respective applications and create important markets. In Abu Dhabi, some 10 MW plants have already been installed and connected, while a 100 MW project is still in the early stage [89]. In Oman, with the help of Masdar, the new wind energy farm is at the construction stage, and with the help of Glass Point, the world's largest solar trough system 1024 MW will be opened in 2017 in Southern Oman.

11. KSA and UAE moving toward to renewable energies

The GCC countries are still lagging in the application of renewables, but they recently have started overtaking crucial steps. The lack of sufficient awareness is one of the reasons for this lags, especially decision makers. Relatively due to the high capital cost, there is a fear of moving from secure and conventional energy resources to uncertain and irregular clean renewable energy sources. Many factors are behind this fear, such as the lack of clear regulations and incentives, lack of industrial motivation, and lack of expertise and know-how. Moreover, there is adequate lack of information about these new technologies. The primary incentive to move to renewable energy in the GCC countries is driven mainly by climate change obligations, as all the GCC countries signed the Kyoto Protocol. Table 5 summarises the concerns of the GCC countries regarding climate change [90].

The second incentive is to meet future energy demand. Indeed, the GCC is one of the regions with the highest per capita energy consumption. The efforts in the region must focus on renewable energy applications and Demand-Side Management (DSM) options. Unfortunately, the major barrier to any serious renewable energy application and DSM actions is the heavy subsidies of energy prices,

Table 5
Climate change concerns in the GCC region [90].

Ratification of Kyoto Protocol	All in 2005 except Bahrain in 2006
Administrative capacity dealing with climate change issue	• Bahrain: Public Commission for the Protection of Marine Resources • Kuwait: Environmental Public Authority • Oman: Ministry of Environmental & Climate Affairs • Qatar: Supreme Council of the Environment & natural Resources • KSA: Presidency of Meteorology & Environment • UAE: Ministry of Environment & Water Resources
Government Declared Targets	No targets except Abu Dhabi has decided 7% reduction in CO2 emissions using 7% RE by 2020
Implementation policies	No clear policies
Large scale pioneer RE projects	• Bahrain: World Trade Center • Qatar: Energy Center • KSA: Solar village (Sustainable campus of KAUST) • Abu Dhabi: Masdar city
Registered SDM projects	Very few
Oil reservoirs (PB survey 2007, if production continuous at the rate of 2007)	• Bahrain < 20 year • Kuwait > 100 year • Oman: 21 year • Qatar: 63 years • KSA: 70 years • UAE: 92 years (Abu Dhabi 95% of production)
Solar energy potential	Very good opportunities
Potential of wind electricity generation	Bahrain, Kuwait, Oman and Qatar: moderate opportunitiesKSA and UAE: moderate potential

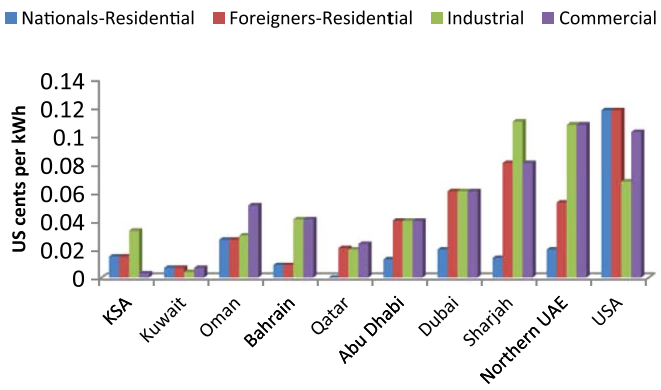

Fig. 6. Retail electricity prices in the GCC versus the US in 2011 [91]..

which are a characteristic of all of the GCC economies. Fig. 6 shows the retail power costs in the US versus those in the GCC in 2011. All of the GCC countries have set relatively cheap prices that encourage more energy consumption and waste [91].

The spread of renewable energy usage diverge dramatically from state to state in the GCC region, depending on several factors, including the political will, laws, regulations, and legislation, and the interest of the Department of Energy. In fact, looking at the differences between these countries it is clear that the institutions have the same functionality, but multiple forms. For example, the six countries in the GCC have created institutions for renewable energies to facilitate and encourage free renewable energy projects. As an example, KSA has established King Abdullah Renewable and Nuclear Energy City (KACARE) [92,93].

The ability of processing of alternative energy applications in the last few years in the GCC countries has evolved with the presence of many challenges. In spite of the different stages of development of the wind and PV energy market, it may be considered in the process of maturity and competition. As for the developing CSP market, there are several opportunities at the lower end of the value chain while the cost of the large parts is still under study and exploration to reduce its prices. There are few international companies that own the intellectual rights to these technologies and refuse to allow local stations in this area to be established. Moreover, the creation of renewable energy systems in the region is still far from optimal despite the encouraging signs, such as specialised institutes such as Masder.

11.1. Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia provides local companies to work in line with the broad objectives for the development of the local renewable energy industry with a focus on special training, creating job opportunities, and research and development. In February 2013, KSA released a White Paper dealing with expected KACARE operations to compete. This programme aims to install 54 GW of renewable energy by 2032. There is local interest in the evaluation of the projects according to high standards by placing rounds of licenses (KACARE) and will increase allocated financial provision values for this purpose [94].

The importance of national sources is clear in the White Paper and it indicated that "while the KACARE has a severe chase for the developments of the local series, it is expected, accordingly, to raise questions about these projects to ensure local importers". This programme requires the development of an investment sector in the local economy by providing training, research advice, and the attainment of local manufacturers. Taxes will be put on special projects and financial allocations for the income from the training new workers on the PV and CSP systems.

The KACARE put incentives to hire local labour. The developers, who are among 5% of the biggest recruitment companies in KSA, will

give more than the overall average salary for each employer. KSA can be considered a late newcomer regarding renewable energy by establishing KACARE in 2010, and the release of its national Strategy and White Paper in 2013. The size and value of investments expected up to 2032 may act as a capable in building efficient events and suitability in the KSA in the coming years [95].

11.2. United Arab Emirates

Despite the lack of a federal energy policy, Abu Dhabi's efforts laid a pivotal foundation in the United Arab Emirates through Masdar City, which is owned by the Abu Dhabi government. Investment in renewable energy in the UAE shows what might seem the presence of about 66 local companies participated in the project Shams 1 (CSP plant with 100 MW). Local renewable energy investment agencies also grew such as Masdar and Taqa to become global investors. Masdar has invested in London (the world's largest offshore wind farm). It also has invested in Gema solar, the Spanish CSP project that uses breakthrough energy storage technology. The UAE has fostered R & D and "thought leadership" through the Masdar Institute and by hosting the international organisation IRENA with its 159-countries members. The Masdar Institute has produced many patents in clean tech, some with start-up potential. The Masdar City sustainable development and free-zone also have brought a raft of renowned renewable energy industry leaders, such as Siemens and General Electric, to establish their regional headquarters in the UAE. The Emirate of Dubai's plans for 1000 MW of solar have further reinforced the "hub". The northern Emirate of Ras Al-Khaimah has pursued a similar approach on a smaller scale with the establishment of a clean-tech campus by Switzerland's respected École Poly technique Fédérale de Lausanne. A related clean tech research and demonstration center run by the Swiss outfit CSEM was also established [96,97].

Nonetheless, given the limited market size at the moment, the UAE has focused more on investing in overseas manufacturing (such as in Germany) than on developing local industry. With KSA looking to take the production lead in the GCC, the United Arab Emirates might well have to forgo traditional local-content focus. However, given Dubai's large financial industry and Abu Dhabi's innovation efforts and state funds, the UAE might see a more professional approach to "local content" emerge: a nation of fund managers instead of factory workers [98].

11.3. Bahrain

Bahrain installed a windmill in the 1950s and the newest one was installed in 2007 to produce electricity for the Bahrain World Trade Center. The windmill consists of three parallel wind turbines; each turbine has blades with a diameter of nearly 30 m, and its total power output reaches 0.66 MW. They were expected to provide 11–15% of the total electricity consumption of the World Trade Center in Bahrain. In 2009, a solar and wind hybrid pilot project was established with a capacity of between 3 and 5 MW.

11.4. Oman

The total renewable energy installed in Oman up to 2009 was 235 kW. The electricity regulation authority in Oman confirmed a shortlist of six renewable energy pilot projects: (i) a 100 kW PV solar project in Hiji using thin film and monocrystalline panels; (ii) a 292 kW solar project in Al Mazyonah; (iii) a 1,500 kW PV project in Hiji; (iv) 28 kW PV Al Mathfa solar project, incorporating battery storage capability; (v) the Masirah Island 500 kW wind project; and (vi) the Saih Al Khairat, Wilyiat of Thumrait 4,200 kW wind project. Also, the Majan Electricity Company installed 50 kW grid connected PV system. In addition, Rural Areas Electricity Company (RAECO) installed a 50 MW wind farm in Southern Oman. Finally, a 1024 MW solar trough plant will be installed to produce steam for oil enhancement recovery in 2016–2017.

11.5. Qatar

Qatar, which won the right to host the 2022 World Cup, has called for the rapid deployment of additional renewable technologies. Qatar intends to host a low carbon event. The country is building a Polysilicon production plant, which is an important component of the solar PV Company in RasLaffan industrial city. This complex is a combination of several companies calling themselves Qatar Solar Technologies (QSTec), with a capital of a 1000 million US$. The company consists of the Qatar Foundation, SolarWorld AG, and the Qatar Development Bank. Initially, the plant planned to produce 8000 t/y of Polysilicon.

11.6. Kuwait

Kuwait has planned to produce 5% of its requirements of electrical power from renewable energy generation by 2020. In June 2013, the Kuwaiti government invited bids to establish a 70 MW solar farm by 2016.

12. The best renewable energy options in the GCC region

The creation of a secure investment environment in renewable energy needs a clear political commitment. This policy requires the development of an ambitious and achievable targets application, building the framework of a structured transparent as possible, simplify administrative procedures, the integration strategy on alternative energies with the general energy strategy and modernisation of the sources of income by creating new productive projects. An effective support system is required here to boost investor confidence and prevent and reduce investment risks in the areas of non- profitable or meaningful benefit [99].

Energy policy gives governments the ability to make decisions that address issues of energy development. This includes building an energy industry and all aspects related to energy such as production, distribution and consumption. Energy policy includes legislation, international treaties, and incentives for investment. The strategic target is energy generation and energy conservation. It aims to stimulate the energy industry, taxes and other policy measures by focusing on new renewable energy sources [100].

The sun's energy can be obtained by distributed PV systems or large central solar thermal power stations. Solar energy alone can provide electricity to a variety of locations: PV systems do not require a grid, and thus may be employed to serve rural demand while solar thermal power stations are best suited for high demand urban areas [101]. Until recently, most of the activities of GCC countries related to renewable energy sources were still at the research stage. KSA, for instance, conducted research studies in solar, hydrogen, and rural PV. Research conducted by Kuwait includes PV, Solar Water Heaters (SWH), and solar desalination. Bahrain research includes wind, SPP, and SWH. Oman research includes wind and PV. UAE activities include PV and SWH. Qatari research has focused on solar ponds and PV. GCC countries appear ready to go forward in a more active role in the development of environmentally friendly, renewable energy technologies. Solar energy could be the most common renewable energy of the GCC and it will be a priority. Solar energy utilised by PV and solar thermal applications.

The PV technology utilises a semiconductor material that can adapt free electrons, the particles with negative charge form the basis of electricity. Silicon is the principal semiconductor material employed in PV cells. Silicon is an element found mostly in sand. All PV cells possess two layers of such semiconductors at least, one negatively charged and one positively charged. When solar radiation falls on the semiconductor, electricity flows due to the electric field generated

across the junction between these two layers. The higher the solar radiation intensity, the more electricity generated. The PV system does not need bright sunlight to operate, and it manages to produce electricity even on cloudy days [102].

Solar thermal technologies concentrate energy by heating up water in a dark vessel. The heat is then transferred to operate a conventional power cycle. The heat may be preserved to be utilised at night by storing it in a liquid or solid media such as molten salts, ceramics, concrete, or newly developed salt mixtures. Concentrated solar power can either focus sunlight directly on solar cells or produce electricity using an intermediate, such as water heating to operate steam turbines. It may be used for domestic water heating, space heating in residential and commercial buildings, industrial heating, solar-assisted cooling, swimming pool heating, and the desalination of drinking water [103,104].

PV will become the cheapest form of energy generation in the foreseeable future due to the cost decreases. PV has begun in recent years to attract considerable interest that evokes the enquiry for developers of which PV technology is most suitable for the GCC region. In the last few years, c-Si PV technology has enjoyed a revival over thin-film technologies due to per-watt module costs and lower panel costs, and also due to higher module efficiencies. CSI is now also more familiar to ordinary people [105] (Table 6).

Considering the specific climatic conditions of the GCC region, Concentrated Photovoltaic (CPV) technology is very promising for all solar power plants in this region. Of course, solar energy technologies are being developed continuously and some of these techniques may change soon [106]. The solar technologies in the GCC region are subjected to dust and soot accumulation. Fog and mist can stick to the collector's surface. The abundance of dust accompanied by fog and mist from time to time will hamper the output of any solar power station (see Fig. 7) [107,108].

The development of wind and solar energy is essential to the GCC region due to oil and gas depletion and related difficulties. The GCC countries must continue to reduce the consumption of low-cost electricity to reduce fuel subsidies (oil and gas). The development of technologies that fit the local conditions of the GCC must taking into consideration the humidity and dust conditions in the region. This can lower the costs of renewable energy if the GCC continue developing areas such as research, demonstration and experience to invest in renewable energy. The funding for this strategy is not a problem and must not concentrate on unique technologies. It is important to give attention to views of technologies including processes, material and energy flows. The GCC countries put targets on renewable energy generation. The UAE has a 7% target for renewable electricity generation by 2020. Bahrain and Kuwait have set 5% targets. Also, KSA and Oman have a 10% target for 2020 and 2030, respectively [109,110].

Table 6
Renewable energy targets in GCC [110].

Country	2020 Target	2030 Target
Bahrain	N/A	5% Electricity generation
Kuwait	5% Electricity generation	10% Electricity generation
Oman	N/A	10% Electricity generation
Qatar	6% Electricity generation	20% Electricity generation
KSA	N/A	30% Electricity generation
UAE	Dubai: 1% of installed capacity Abu Dhabi: 7% of Electricity generation	Dubai: 7% of installed capacity Abu Dhabi: N/A

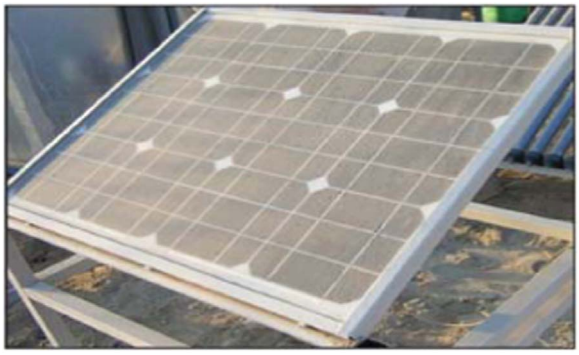

Fig. 7. Sample of dirty PV panel due to accumulated dust deposition [107].

13. Discussion and analysis

13.1. Changing the GCC energy profile

Based on the level of production compared to the amount of resources they have, the oil exporting countries are facing depletion on different time scales. As oil production reaches its plateau, export levels tend to drop while the domestic consumption rises. This is the typical depletion trajectory of petroleum exporting countries. Resolving this dilemma is: first increasing the oil price to a level close to export prices, which will result in a decline in export revenues. The second solution is by increasing energy and fuel prices for domestic consumption. As depletion starts, both production and exports are reduced. When export levels fall below domestic consumption, the country becomes a net importer. This scenario indicates that to attain maximum benefit from natural resources, careful consideration of domestic use is required [111].

Renewable energy technologies have many benefits including energy security, job creation, investment opportunities, sustainable development and the prevention of global warming [112]. Increasing the share of renewables is an effective approach for reducing the combustion of fossil fuels and climate change. Currently, the US, Japan, Germany and Brazil have started to develop renewable energy plans as an important part of enhancing their environment in the future [113]. As renewable energy usage and development depend mainly in the GCC region on political decision-making and support, it is expected to become progressively cheaper shortly. The deployment of renewables in the GCC region has grown at a very slow pace over the past few years. Unclear plans for the future of energy in GCC countries with fluctuations in oil and gas prices and the depletion of reserves as well as no strategic plan for renewables or a clear target.

Governmental policies reflected on renewable energy utilisation since 2008 still do not compete with fossil fuels and depend on government support only. Government subsidies for fossil fuels hamper the development and support of renewables. With their abundant solar energy potential and large financial resources, the GCC countries have an opportunity to establish a world position in this energy. Moreover, these countries can carry out further development of relevant technologies. This issue involves the development of an advanced professional skills base in science and engineering. It might logically be expanded to provide a specialisation in modern solar-efficient architecture and energy management. The success of renewable energy deployment in the GCC region will depend on proper regulations and policies, as well as fiscal incentives [114,115].

13.2. Switching to green energy

The GCC countries, in addition to Iran and Iraq, represent the largest store of oil in the world. They contain about two-thirds of the world's crude oil reserves and produce up to a quarter of global oil production. The huge revenues from oil and gas have transformed this

region over the past hundred years into the most important financial and economic power in the world. The GCC region can be observed as fast and high level growth. In spite of this growth, the need for a link to the food and water processing and provision is even more. Since these countries are located along the coast, as it is an important source of alternative energy it is also contains a great source of fish [116].

Almost all the coastal towns of the Arabian Gulf were trading centres. These cities changed from being small settlements into large, modern cities following the discovery of oil in the 1930 s. The dramatic growth of these towns makes them major ports for oil storage and transport.

Not surprisingly, the very rapid growth and development of the region has affected its environment. Achieving an acceptable balance between urban growth and environmental protection is the most important challenge facing the region. Soon, renewable energies, energy intermittent, renewable energy storage, and smart grids that distribute generated power initiatives to raise energy efficiency. These facilities will make the interconnection of the GCC countries catch up with China and Europe in the development of alternative energies. Work on the replacement of cheap electrical energy produced from oil and gas with more expensive renewable energies is considered a major challenge in the region. Even today, solar electricity production is still expensive than conventional electricity. However, by 2020 it is expected that the GCC countries will be able to supply solar energy with an electrical networks processing capacity equal to those generated by traditional methods. The GCC countries can by important knowledge determination and an important source of funding to overcome European countries easily in the solar energy production rates by the potential available solar energy.

Many renewable energy projects in the region have been constructed in the last few years. KSA established a new initiative in 2011 in King Abdullah City for Atomic and alternative energies. The programme aims to develop knowledge and produce a third of the Kingdom's electricity needs by these sources. By 2032, the KSA aims to produce 42,000 MW by established solar plants. Currently, 16 MW power produced of PV plants and up to 25 MW power produced by concentrated solar power plants [117]. The project costs billions of dollars and aims to put KSA at the forefront of alternative energy development [118].

In the UAE, Abu Dhabi has taken significant steps in RE development. The Masdar Eco-City project started in 2008 and is now well under way, though scaled down in ambition. The Masdar project aimed to become the world's most sustainable low-carbon city by powering the city by the sun and cooling it by the wind. Masdar used architecture and urban planning to incorporate traditional concepts such as exterior walls, shaded windows, narrow streets, walkways, courtyards, wind towers, thick-walled buildings, vegetation and pedestrian zones. Today, Masdar's streets are cooler by up to 15 degrees compared to city streets in downtown Abu Dhabi [119]. In addition, Masdar, as a research base in the region, has started a research project to develop non-stick coatings that will enable solar panels to withstand sand and dust better [120]. Masdar has become very important and large learning laboratory with new approaches to urban planning and the use of renewable energy technologies.

The GCC is forced to deal with a world of rapid urbanisation, which represents a fundamental lack of systematic correlation in the relationship between human and nature. Therefore, the integration of urban plans in GCC countries as part of the control is important to get a capable and processing of energy, power transmission policy, construction development, investment, water, and dining together in an integrated process with the inclusion of middle class education at the same time. Moreover, the chart appears to run cities and the rule of important new opportunities to create new jobs and restore economy activity. There is a need to develop new integrated thinking with an informed understanding of the work of complex natural systems. All of these things will provide clean environment for a long period in the region [121].

Enormous wealth, investments and revenues make the GCC region powerful politically and economically. The military intervention in Libya in 2011 heralded a new kind of power and influence in the Middle East. Qatar and the United Arab Emirates have worked to ensure the stability and prosperity of the world in spite of the arrival of popular protests from some neighbouring countries from GCC countries. The two countries have led the Arab military action in Libya with confidence. This trend came from the vision of the leaders of Qatar and the UAE as regional powers. This came three months after Qatar was awarded the FIFA World Championship in football in 2022 and underlined the global role that the GCC is playing [122,123].

The KSA assault on Yemen and the approval of United Nations (UN) consensus for it is interfering in the neighbourhood country clarifies the political weight for these wealthy countries. These highly centralised countries mean their rulers are free from many of the constraints of states with more participatory political systems. All GCC countries except KSA are characterised as ‘micro-states’ by researchers [124]. Today, after extraordinary levels of immigration, the population of these countries have trebled meaning they are no longer ‘micro-states’. However, neither their small areas nor populations have forced the projection of power and impact at levels that far defeat many larger and more ‘powerful’ states.

Many factors have enabled the GCC to overcome the constraints hitherto placed on small states in the international system. First, a generation change of the rules that unfolded over the decade and a half after 1990. The new rulers have modern qualifications and professional training that make them more educated. The new rulers differ from earlier generations of GCC rulers who spent considerable time struggling with the challenges of building and consolidating bureaucratic structures and institutional frameworks. This transition has not yet occurred in Kuwait, Oman, or KSA. However, in Qatar, Bahrain and the UAE an entrepreneurial spirit has been generated and even encouraged [125].

The levels of precious resources and smaller populations have provided the rulers of Qatar and the UAE with insulation from domestic social actors and economic interests compared to other GCC states. The moderate degree of institutional consolidation and reform of governing and regulatory structures in the 1990s and 2000s mean that political power and authority in Qatar and the UAE have remained embedded within small circles of policy-makers clustered around senior members of ruling families [126,127].

The changing nature of the concept of power itself in an intensely interconnected world enabled small states to project greater power internationally. The acceleration of globalising forces during the 1990s and 2000s worked on integrating states and societies in international systems and networks of interaction. The opportunities for small states with economic power and influence such as the GCC States could allow them to take advantage of the leverage and opportunities accorded by rising oil and gas revenues, and they can have political stability, a haven for foreign business and investment, and economic liberalism [128].

13.3. The effect of a low carbon strategy on the GCC alliance

The development of world-class projects such as Masdar City in Abu Dhabi makes great returns and great wealth by the GCC region as a major role for sustaining the momentum of cooperation among them. Currently, KSA leads the GCC countries in the field of carbon-free projects while Qatar and the United Arab Emirates are involved in a new framework to govern international energy and climate change policies. Qatar worked hard to gain the right to set up the main center of global alternative energy in 2009. By doing so, it gave a signal for the first time that a global organisation has established itself in the Middle East [129]. Qatar is also leading a group of countries exploring gas across governmental organisations and these countries include Russia,

Iran, and Venezuela [130]. Moreover, Qatar became the first country of the GCC and OPEC countries to have developed a policy on climate change. It can be seen that all these steps referred significantly to the selection of Qatar as the host for the eighteenth Convention of the Parties (COP 18).

The GCC countries have managed to integrate themselves into the global economy through governmental channels mostly. The importance and effectiveness of these countries to participate in establishing of the international policy and economy will not lessen with time. On the contrary, it will increase as indicated above. The rapid rise of GCC countries as economic and political global players had been realised with the help of the unprecedented rise in oil prices coupled with the large accumulation of capital and the policy orientation of spending and the use of the profits. Last, but not least, there is the fact that the global system is in the process of continuous change. These conditions created many opportunities for GCC countries to contribute effectively to restoring balance to the geo-economic ability [131].

The increasing importance of the GCC countries during the first decade of the twenty-first century is not only due to their significant oil and natural gas reserves. In addition to its important geographical location between East and West, the rich GCC can today play a central role in changing the shape of the global economy. Political decisions about how to utilise the accrued wealth are equally significant, in large part through sovereign investments. The GCC countries understand the importance of investment. The Abu Dhabi Investment Authority was established in 1976 and in 2005, the Qatar Investment Authority was established. They are made up of a wide range of stakeholders such as Abu Dhabi's Mubadala investors (in 2002) and Qatar Holding the hand of the Qatari government for investment (in 2006).

The UAE has expanded their vision through a burgeoning relationship with South Korea to build a nuclear power station. This contract was signed by the Emirate Nuclear Energy Corporation (ENEC) and a combination of companies led by the Korea Electric power Corporation (KEPCO). Four nuclear reactors will be set up in the western sector of Abu Dhabi [132,133].

The creation of environmentally liberal cities in the GCC is a challenge that must be faced by politicians and decision-makers in GCC countries. These countries aim to set up a new integrated model of civilian rule, which means finding effective ways to identify the waste of public resources [134]. The creation of life systems depends on the vitality of a long period of government intervention, which goes further than current models. The civil administration needs to stretch beyond the physical boundaries of the city to include the attention of decision-makers to reduce environmental impacts. This is required from GCC countries, more urgently than ever, to collect energy and management policies in an integrated process. It is important to engage education as a vital, as well as the middle class at the same time [135,136].

Today, it can be considered a new challenge to formulate the principles of open government credible and understood that awareness prone cities significantly to the degradation of natural systems that rely on survival for long periods without causing significant changes in its policies and strategy. In this area, all of the GCC countries work together, or separately, to bring about this change. The countries of this Council need to set up a new integrated system of thinking to confirm the environmental viability of life on how long systems vital GCC. A good understanding of the requirements of the newly generated civilian regimes should be supported by modern techniques and policies, new civilian positions, and more than all of the above, new ways of governance. This is a real test to get to the more challenging results and thus increase revenues [137].

13.4. Policy inclusiveness and niche development

The sociotechnical alterations for sustainable energy usage involve many actors and intricate processes of change. For example, there are increasing needs for electricity to be produced by renewable technologies as a result of global warming. This goal can realise as commutative steps, for example, the UAE aims to increase its share of the renewable electricity generation and introduce new players in the electricity industry. Although renewable sources of electricity are on the rise in the UAE, fossil fuels and conventional power generation technologies are still dominating the electricity sector [138]. Despite the efforts to privatise and liberalise electricity markets, the alteration in the electricity sector has been modest. There are many differences between the GCC countries that are quite clear concerning renewable electricity generation and the liberalisation and privatisation of the market [139].

Looking at renewable power generation in more detail by using wind energy and PV as examples, wind energy generation is limited in Bahrain and Oman while PV electricity generation is used widely. The GCC countries also differ from each other considerably in the ways domestic electricity markets have been liberalised and privatised [140,141].

There are many differences in the scope of liberalisation of the electricity sector of these countries. The socio-technical changes originate from niches strategy is slow because some groups inside the system are resisting change. First, these niches are protective spaces, temporary sites that allow experimentation with the co-evolution of technology, user practices, and regulatory structures, outside the regime and its selection criteria. Second, the resisting regimes are influenced by their institutional and the criteria for innovations. This refers to the established structures, conventional technologies and infrastructures, conductor principles and socio-epistemic processes, political power, and the cultural importance of these regimes [142]. These regimes can impede niche development, and they can turn a niche into a growing innovation. However, niches may be highly developed outside of the regime's influence [143].

Niche development depends mainly on radical innovation and requires alterations in the selection criteria that require changes in parameters [144]. Niches are developed by their actors, who may be scientists, engineers, or common people who are interested in niche development. Many early researchers concentrated on the internal activities of niches, such as learning processes, building on social networks. In recent research, concentration on the improvement of the quality of learning and institutional is embedding to enhance niche development [145].

Political support is crucial for the development of a niche by creating many changes in policy measures for the executive role. Always, there is a difference between the theoretical ideas considered and the reality, and the government is always involved in the politics of changing processes [146]. There is much information that is interested of the public and demand for existed renewable energy technologies. The role of public interest in niche development needs to be studied in greater depth. Sustainable changes have been studied as technological changes and less attention has been spent on other areas of sustainable development, such as increasing citizen participation and democracy [147]. Thus, for GCC states more information is needed about democracy, citizen participation, and niche development.

If we take PV and wind energy as niches that must be analysed, there is no strategic niche management or simple tools for evaluating the scope of sociotechnical changes. For example, if a change is called a regime change when it is an incremental change, we understand this change as a shift from traditional energy-based fossil fuel electricity generation to the employment of renewables by young and medium scales consumer-owned generation. This kind of alteration would increase sustainability, including democracy and citizen participation, as the ownership of the generating capacity would be distributed among a large number of actors [148].

Following the events of Arab Spring, the GCC governments understand that they cannot ignore public opinion anymore. The influence of public opinion on policies is a very complex and contested issue. The social influence on policies becomes independent on the electoral

system and political institutions. The direct responsibility linked to local policymakers gives them more incentives to represent public opinion and vice versa [149,150]. The important role of the public is to keep salience unless the public is interested in these matters. The public does not care about policies if they are not related to their lives. Renewable energy technologies related to environmental problems and ideologies. The influence of environmental issues on the public is not constant but fluctuating. For example, nuclear energy has given momentum to the new parties and the renewable energy-electricity technology development in many European countries. The salience of renewable energy technologies increased again from being an ideological or perfect alternative to nuclear power. It is commercially available to consumers, and more tangible and viable alternatives to buying electricity from the grid. Renewable energy technologies offer many advantages for private consumers, such as the ability to manage a private power economy, e.g. facing the rising electricity and grid costs. Besides, consumers would be less exposed to technical or market failures, such as blackouts and price hikes.

13.5. Critical appraisal on research conducted

Research and survey conducted for the potential, production, demand and prices of oil and natural gas in GCC countries has been discussed. The following is the main highlighted points from this study:

1. The combustion of fossil fuels continues to rule the international energy market that is fighting to meet the increasing demand for fuels used in heating, electricity and transportation. It is a fact that the international energy supply will remain dominated by fossil fuels for several decades to come.
2. The increase in tight oil and shale gas production will affect KSA, the oil largest exporter in the GCC, and other GCC countries to different extents.
3. Energy and environmental policies need to be specific in the future. The energy and environment co-benefits should be taken into account when making plans.
4. Several countries have adopted policies resulting in the successful implementation of renewable energy systems. These systems give confirmed benefits associated with energy access and distribution, health, equity and sustainable development.
5. The main objective of any energy transformation must be to supply energy services that enhance the quality of life (e.g. health, life expectancy and comfort) and productivity.
6. Although overall electrification rates in the GCC region are high, improved living standards in recent years, accompanied by the area's expanding petrochemical industry have increased the area's energy demand. Energy consumption levels are expected to rise by about 1.9% per year between 2012 and 2035. Population growth and economic expansion increased energy demand significantly between 2000 and 2011. Domestic consumption has doubled in Oman and tripled in Qatar.
7. The oil wealth of the Arab world has shaped its developmental trajectory. The GCC countries are the most world source suppliers for oil. The GCC region has a central position in international crude oil trade and affected its markets. Oil revenues are considered as a key source of affluence for the GCC region as a whole. This wealth has driven the socio-economic model in the region.
8. The oil income in GCC countries has made their economies interrelated and dependent mainly on energy revenues. These countries do not have diversified economies and depend primarily on the export of this single commodity. Energy incomes in the GCC countries provide a source of economic growth and industrial development. Moreover, social and political stability rely on it.
9. Almost the entire GCC region, from powerhouse exporters such as KSA and Qatar to the weaker ones like Iraq, Bahrain and Oman, has tried to manipulate oil prices. During periods of price fluctuations such as Arab Spring, these governments increased the substantial subsidies that may bring stability to their countries. Almost all of these countries have increased subsidies hoping of reducing consumption and increasing social stabilities.
10. It is found that different political and economic factors influence, limit and impact energy sources. The rich GCC countries (UAE, KSA, and Qatar) remained untouched during the period of unrest (Arab Spring) that affected parts of North African Arab countries.
11. The GCC countries are facing a threat from shale production today. International abundance of shale reserves has not yet been fully realised. Increases in social expenditure commitments make GCC governments more dependent on oil prices to balance their budgets. This dependency makes them more susceptible to petroleum prices. The usage of subsides was a definite sacrifice to achieve political stability.
12. Oil producers in the GCC have faced many challenges in the last decade. These challenges have included investing in the energy sector accompanied with high uncertainty due to climate change. Moreover, an energy security policy aimed to reduce oil dependency in the energy outlook. These countries technical and managerial capability reinforcements to transfer their industries to create jobs opportunities for hundreds of thousands of employees joining the labour market every year. The enhancement of private sector roles and regional connections has been used to diversify domestic energy sources away from oil and gas towards renewable resources.
13. The GCC countries have failed to separate economic growth from energy demand in the past decade. Therefore, the GCC economies are among the least efficient in the world. Energy consumption growth is faster than economic growth in the region. The annual increase in energy and electricity need has been about 8%. Subsidies on fossil fuels are considered as the primary contributing factor to this inefficient use of energy. An important factor causing this is the weak electricity infrastructure in most countries in the region.
14. Political support for changing to renewable energies is crucial for its development. There is evidence that there is public interest in and demand for renewable energy technologies. Sustainable changes have been studied as technological changes, and less attention has been paid to some other issues of sustainable development, such as increasing citizen participation and democracy. Thus, for GCC countries, more information is needed about democracy, citizen participation, and niche development.
15. Sustainable energy in GCC countries has been considered since 2008. Resource efficiency programmes, alternative energy projects, clean technology research, green building codes, public transport systems, and green economy strategies have become a part of mainstream news. The GCC countries have started to have a stake in the sustainable energy transition.
16. The GCC countries have already undertaken many policies, projects, and sector extensive efforts. These projects, if implemented, will create a variety of business, and its will have positive impact on the environment. Many of these policies and projects, however, still exist only on paper. Solar energy applications and green building codes are priorities.
17. Over the past two years, the GCC countries have moved towards a constructive approach to renewable energies. In 2012, upon the proposal of KSA, the UAE, Qatar, and Bahrain, parties to the UN climate convention agreed that hydrocarbon-dependent economies could present their mitigation and other climate actions up to the international standard, under the umbrella of economic diversification and sustainable development strategies. The GCC states are yet to register any actions under this concept, but may do so shortly.

14. Conclusions

The Gulf Cooperation Council (GCC) countries are considered as the largest producers and exporters of oil and gas in the world. In the same time, their oil and gas consumption for electricity production grows profoundly, which cast its shadow on the economic status of these rich countries. The continuation of the growth in the oil and gas consumption rate will cause a severe decline in the export of these materials, which has an adverse impact on the economies of these countries. The oil prices fluctuations have hit the Gulf Cooperation Council (GCC) twice. When the prices rose, the energy subsidies provided by these countries to support the energy costs caused a severe impact on the economy. Also, the drop in oil prices caused stopping of thousands of projects due to lack of funding. GCC states have launched a sense of the importance of converting part of its electrical energy produced by fossil fuels to alternative energies. After doing thousands of studies and survey potential in this direction, today we see many of the projects towards the use of renewables. Although these projects are still below the level of ambition, the enormous economic potential of these countries with the proper planning and the existence of several partnerships with advanced companies in this area, the GCC can achieve the ambition during the next two decades.

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